

AGRICULTURAL MACHINERY MAINTENANCE
IN DEVELOPING COUNTRIES

BY

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INTRODUCTION

Too often, the term Agricultural Mechanization is confined to tractors only. Mechanization certainly covers more than that. According to Von Hulst (1974) of the FAO, Agricultural Mechanization is concerned with the operation, maintenance, repair, and marketing of agricultural tools, implements, machines, and equipment which enable the raising of productivity of human labor. Out of the four concerns of mechanization, only the maintenance aspect is treated in this report.

All of the factors that include agricultural mechanization are referred to in one word as machinery. It includes mainly tractors and implements. All the discussions in this report are centered around the tractor, because it is the major tool for mechanization, especially in developing countries.

Maintenance as defined by Crossley and Kilgour (1983), is a combination of any actions carried out to retain an item in, or restore it to, an acceptable condition. In today's world of high technology, there is a new term that brings all aspects of maintenance under one heading. This word is called Terotechnology. Terotechnology is defined as a combination of financial, engineering, management, and other practices applied to physical assets in pursuit of economic life cycle costs. It is concerned with the specification and design for reliability and maintenance of plant, machinery equipment, buildings, structures with their installation, commissioning, maintenance, modification, replacement and with feedback information on design, performance and costs (Dept. for Industry, 1975).

In light of agricultural machinery or tractors, the principal objectives of maintenance/terotechnology are fourfold:

1. To extend the useful life of the tractor,
2. To ensure the availability or readiness of the tractor,
3. To obtain maximum return on tractor investment,
4. To ensure safety of personnel and bystanders who use or come into contact with tractors.

There are two kinds of terotechnology/maintenance, Viz. unplanned and planned. Further, there are two types of planned maintenance: preventive maintenance and corrective maintenance. All these areas are fully covered in this report.

In agricultural machinery maintenance, it is good advice to use the look, listen, and feel approach, because a few moments of maintenance work can save many long expensive breakdowns.

OBJECTIVES

The primary objectives of this report are:

1. To determine the sources of agricultural machinery in developing countries.
2. To determine the stage of agricultural machinery maintenance/terotechnology in developing countries.
3. To examine the problems of agricultural machinery maintenance and new approaches to maintenance in developing countries.
4. To establish a model for maintenance programs in developing countries.
5. To draw up conclusions and recommendations based on reviewed literature.

LITERATURE REVIEW

According to Gego (1986), mechanization is the completion of farm operations with minimum use of manpower, within a short time, at a low cost and with increasing quality.

From the paleolithic times, there has been shift of power sources for mechanization:

1. From human to animal (workstock),
2. To water and wind (windmills),
3. From steam to internal combustion engines and electric motors (Binswanger, 1984).

The use of machinery in agriculture as the tractorization of agriculture has been much more rapid in industrialized countries than in developing countries. According to Johnson and Hollenberg (1950), factors that accelerated tractorization of American agriculture in the early 1950's were:

1. The wartime period led to limited supply of labor,
2. High cost of keeping workstock/animals,
3. High level farm income permitting the investment necessary for mechanization,
4. Production of adaptable tractor models,
5. A general preference for motorized equipment by both youths and adults.

During this period, the average farm size rose from 17 acres in the 1930's, to 210 acres in the 1950's and to 401 acres in the 1970's.

On the other hand, tractorization of agriculture has been very slow

in some countries. It has not grown rapidly in developing countries, because of the following features according to Crossley and Kilgour (1983):

1. Farm size and structure - 80-90% of farm holdings are below 5 ha and 50-60% are 2ha or less. Small holding system limits mechanization due to the problems of topography, drainage, natural vegetation and accessibility.
2. Population and labor - small farm systems are labor intensive and family oriented. Small holder sector engages over 50% of the economic, active population.
3. Semi-subsistence farming - usually 2-3 ha holdings and generally devotes 60-70% of its area to household food crops mainly root crops and cereals - dryland intercropping.
4. Low and variable incomes - 1.5 tonnes of cereals at \$80 and 1.5 tonne of peanuts at \$250 all ending up at \$250 gross family income for six people.
5. Institutional support - Input supply, marketing, credit, extension, and training are limited and a major constraint to improved productivity.

In developing countries, tractorization is usually associated with labor displacement, that is, employment destroyer rather than employment creator. Abercrombie (1973) estimated in Latin America that one tractor has replaced 2-5 horses and 2 men. McInerney and Donaldson (1975) found that one tractor led to a net loss of eight permanent jobs in Pakistan. Culpin (1969) found in the tractorization of American Agriculture that

machinery has drastically reduced man hrs/ac for harvesting as follows:

1800 - 56 man-hours/acre

1900 - 15 man-hours/acre

1969 - 5 man-hours/acre

Johnson and Hollenberg (1950) found that mechanization of American agriculture has led to a decrease in family and permanent hired labor inputs and this was partially offset by increases in casual labor requirements. Gego (1986) found that with increased mechanization in the development of northern Indian province of Punjab that it was possible to:

1. Improve employment situation,
2. Extend cultivated area,
3. Raise yield, and
4. Augment per capita income.

According to Sargen (1956), quoting Richard Day's views, mechanization displaced labor in a two-stage push-off the farm in southern USA. The first phase was partial mechanization of the pre-harvest operations. The second phase used mechanized techniques for harvesting corn, cotton and tomatoes. But Sargen argued that mechanization was an employment creator, because the increased production created more job opportunities for the displaced labor in the processing factories. To determine whether agricultural mechanization is an employment destroyer, the International Conference of the FAO, Rome, published a report (1975), "The Effects of Farm Mechanization on Production and Employment". The report concluded that there has been no

negative influence of agricultural mechanization on the overall employment situation (Gego, 1986).

In spite of the six uses of the tractor, e.g. for seedbed preparation, planting, cultivation of growing plant, harvesting, transporting and processing, many developing countries such as Mexico and Nigeria are still adopting the Bimodal Strategy. This, according to Sargen (1956), is a system of agriculture characterized by technological dualism:

1. Commercial Sector - utilizing labor-saving equipment
2. Subsistence Sector - relies on traditional technology with manual work plus workstock and increased amounts of conventional inputs.

According to the FAO Report (1974) at the Expert Consultation Meeting on the Mechanization of Rice Production, developing countries should have a good synthesis of cultivation techniques and the use of agriculture machinery and equipment. The report puts the economic life of a tractor at 6,000 hrs. But Johnson and Hollenberg (1950) said that with good maintenance, tractors can still perform at 7,000 - 10,000 hrs.

SOURCES OF AGRICULTURAL MACHINERY IN DEVELOPING COUNTRIES

From the historical perspective of Price (1952), mechanization in U.S. was an evolutionary process. It started between 1850 and 1880 when the farmers adopted the mechanical reaper and the steel plow and substituted animal power for manpower. The next burst was in the 20th century with the introduction of gasoline-powered tractor. According to Sargen (1956), the general purpose tractor was built in 1915 and was fully developed in 1924 to replace the standard tractors. The tracklaying tractor that was more powerful than any of these tractors was used almost exclusively in the West where the terrain was more hilly. The growth of tractors in the U.S. occurred over a fifty-year period and primary tillage operations were shifted to tractors (Binswanger, 1984).

The situation in the developing countries is different. There are three main sources of agricultural machinery in developing countries as reported by Khanna (1983). These sources are:

1. Importation,
2. Local manufacture, and
3. Assembly.

*See Table 1, page 40

It is pertinent to examine the sources of agriculture machinery in developing countries, because it has a great impact on their maintenance.

Importation

Most developing countries such as Jordan, Iran, Iraq, Syria, and

Thailand, import their agricultural machinery (Bergmann, 1984). They found it much cheaper to import agricultural machinery following the economic law of comparative advantage. They exported those goods they found cheaper to produce and imported other goods, including agricultural machinery, they found costly to manufacture.

The importation of agricultural machinery has some advantages. In Egypt, Khalil (1981) said, "the government allows the importation of all kinds of tractors from any country, even the importation of second-hand ones". This made the prices of new tractors competitive in the local market.

According to Sargen (1956), Taiwan and Japan were successful in mechanizing agriculture through the unimodal strategy by allowing free importation of agricultural machinery from all over the world. The unrestricted imports of an array of small engines and parts were used by small innovating firms to design locally adaptable and manageable machines. According to Binswanger (1984), in Pakistan, the government trade policies restricted imports of agricultural machinery and this made mechanization policies to fail. In Thailand, the source of agricultural machinery is through a laissez-faire importation policy by the government. It resulted in the development of indigenous production of power tillers and small tractors and availability of broader machinery options. It resulted in a few adverse social consequences.

Local Manufacture

Some developing countries like Turkey, Argentina, Pakistan, Brazil have national production of agricultural machinery (Bergmann, 1984).

Though the machinery generally is crude, rugged and of poor finish, yet, it possesses some advantages:

1. They are more adaptable and suitable to local conditions than the imported machines.
2. Low price is possible because they have no sophisticated accessories.
3. They are easier to operate because there are no complicated operational gadgets.
4. They are very sturdy and do not breakdown often resulting in low maintenance costs.
5. Increased agricultural machinery technology - One of the best ways to transfer technology to the developing countries is to manufacture machinery locally.

Manufacturing machinery locally can also have some negative results.

1. Machinery costs could be higher; especially when government imposes high excise duty as in Brazil (Abercrombie, 1973).
2. Poor quality products - Inferior material may be used which could result in manpower loss due to frequent downtime.
3. Frequent breakdowns can lead to poor timeliness of farm operations.
4. Local manufacturing can be a risky venture - according to Binswanger (1984), Switzerland had at least five producers of tractors in 1950; but none survived to date.

Assembly

In the 1970's, the trend in many developing countries was the establishment of tractor assembly plants instead of importation or local

manufacture of tractors. Countries like Nigeria, Mexico, Venezuela, Peru and Bangladesh have plants for assembling agricultural machinery. Many of the plants are owned by the home government and a multi-national corporation overseas on a 60% and 40% equity, respectively.

Let us take Nigeria as an example for an agricultural machinery assembly study. Nigeria, the most populous country in Africa with 113 million people according to The World Bank (1984), has two assembly plants: one in Kano and the other in Bauchi. They were established in the late 1970's. The Kano plant assembles Fiat tractors (from Italy) and the Bauchi plant assembles Steyr tractors (from Austria). The components for the machinery were imported CKD (completely knocked down) basis. These components include:

1. Power component - engine
2. Transmission component - belts, chains, etc.
3. Running gear components - wheels
4. Control systems, hydraulics, electronics, etc.

The assembling of agricultural machinery in any developing country has some advantages as well as some disadvantages.

Advantages

1. Conserve foreign exchange, because there are no more fake agricultural machinery importers.
2. Availability of spare parts for the maintenance and servicing of the machinery.
3. Availability of assorted machinery.

4. Machinery prices can easily be subsidized or controlled by the government.

Disadvantages

1. The manufacturing of high technological machines which are relatively non-adaptable and non-manageable in developing countries.
2. Misuse of tractors, because they are too sophisticated for the average farmer to understand and operate.
3. Non-transfer of technology to technicians in the developing countries, because the machinery components are manufactured overseas.
4. Lack of training of craftsmen leading to poor machinery maintenance.
5. Replacement parts are sometimes difficult to obtain.
6. Government imposed high custom duties on the component parts and the high inducement allowances paid by the company to their expatriate staff, often make assembled machinery more expensive than imported ones (Olatunbosun, 1975).
7. There is lack of technical development. The government ban on imported agricultural machinery denies small innovating firms from seeing foreign designs from which to create and produce locally adaptable machines.
8. The production/assembling of giant tractors (80-200 hp) instead of intermediary tractors (20-40 hp), which the average farmer can easily afford, operate and maintain.

Finally, I would like to say that it is my opinion that developing countries should manufacture small-range agricultural

machinery locally. They should allow minimal importation of low horse power tractors at the same time. According to Bergmann (1984), the aim should be:

1. To substitute imported machinery with locally manufactured machinery.
2. To foster independent production and technical development.
3. To adapt some imported designs to national and regional circumstances.

THE PRESENT STATUS OF AGRICULTURAL MACHINERY MAINTENANCE IN DEVELOPING COUNTRIES

Let's examine briefly two variables: the methods and the stage of mechanization in developing countries and the present status of agricultural machinery maintenance.

There are four methods of mechanization according to Johnson and Hollenberg (1950):

1. Ownership of tractor.
2. Tractor hiring unit by government.
3. Custom work by private firms.
4. Cooperative ownership of tractor.

Ownership of Tractor

There are not many farmers having their own tractors in developing countries. The reason is that their average income is very low. In Nigeria, this is about ninety-four naira (#94) or one hundred and forty-one dollars (\$141.00) per year (see Table II, page 40). Though the Nigeria Agricultural Credit Bank (NACB) exists in each state of the Federation to grant loans to farmers, yet they cannot afford a tractor, because they have no collateral security to get the loan. So, only few commercial farmers own their tractors.

Tractor Hiring Unit

This is operated by many governments in developing countries like in Zambia, Kenya, Tanzania, Nigeria, Jordan, Iraq, Venezuela, India, Sri Lanka, and Uganda. The government buys agricultural machinery and loans them out, on highly subsidized rates, to farmers through the Department of Agriculture.

Custom Work by Private Firms

In this system, private companies have their own agricultural machinery which they use in carrying out mechanization operations for farmers. It is in operation in many developing countries such as Turkey, India, Bangladesh, Brazil, Zambia, Nigeria and Senegal. The problems with this method are:

1. High operational charges.
2. Lack of technical knowledge by many operating firms, e.g. construction bulldozing instead of agricultural land clearing.

Cooperative Ownership of Tractors

This is yet at the rudimentary stage in many developing countries like Nigeria, Botswana and Uganda. It is in operation in Kenya, Taiwan, Zimbabwe, Korea, Argentina where the cooperative system is fairly well-developed.

While 82% of the cultivated area in industrialized countries is mechanized with the use of tractors, only 22% of such cultivated area is mechanized in developing countries (see Table III on page 41). The relevance of these facts to this study is that they reveal the low level of agricultural machinery application in developing countries. Machinery is regarded as unimportant in farming and its maintenance is regarded as insignificant too. This is one of the severe problems of agricultural machinery maintenance in developing countries.

According to Khanna (1983), the report on the "need for tractor" in the Chambal region of Madhya Pradesh in India showed that about 72% of the people responded as having no need for tractors (see Table IV, page

41). Since this large number of people do not think that they need the tractor to farm, they will not have any desire to maintain it, even if it is given to them by a government. This point was vividly demonstrated by the "village scheme program" that was executed in Nigeria by the Benin-Owena River Basin Development Authority between 1981 and 1983.

In that scheme, the Basin Authority bought 20 pieces of Universal Tractors (Romanian products) from Yakon Company of Box 54, Benin-City. I was the sale manager of the company in-charge of agricultural machinery. These tractors were distributed by the Basin Authority to farmers in Bendel and Ondo States. We carried out the after-sale services in each farmer's farm. After this, the farmers did not do any further maintenance of the tractors. All efforts by the company to make them maintain the tractors proved futile. Within two years, over 80% of the tractors were completely inoperative. The longevity of a well-maintained tractor is about 10 to 15 years; but due to lack of maintenance, the village scheme tractors did not last two years. In the village scheme, the farmers did not truly see the need for tractors to farm. The tractors were forced on them. They were not prepared for them. They were technically deficient. The politicians initiated the program to win cheap votes. They directed the distribution of the tractors to only their political loyalists. This experiment revealed that the present status of agricultural machinery maintenance in developing countries, on the average, is yet very substandard.

According to Crossley and Kilgour (1983), there are two kinds of terotechnology:

Unplanned. This is the sudden malfunction of the equipment that was not anticipated. For example, the operator hears an unusual noise from attached implement. He stops quickly to check for loose bolts and nuts. In developing countries, many tractor drivers are untrained and many do not know that a stitch in time saves nine.

Planned Maintenance. This is a pre-determined and pre-arranged combination of actions to keep the machine in an operative and healthy condition. There are two types of planned maintenance:

Preventive Maintenance. This is carried out at pre-determined intervals, according to prescribed criteria to reduce the likelihood of an item not meeting an acceptable condition. For instance, changing oil filters before they become clogged. Preventive maintenance can do three things:

1. Reduce failures.
2. Save on operating costs.
3. Keep equipment safe - John Deere (1984).

According to Culpin (1969), preventive maintenance saves time and money.

Corrective Maintenance. This involves restoration of an item which has ceased to meet an acceptable condition like replacing a main clutch assembly, when there are signs of malfunction, but before it has ceased to function altogether - *ibid.*

In developing countries, agricultural machinery in general lacks maintenance. The use of machines in agricultural production instead of

either manual labor or workstock (animals - oxen, horses, etc.) still seems to be strange to many farmers. In Kenya, according to Crossley and Kilgour (1983), about 85% of the rural farmers prefer "oxenization packages", which include oxen, a range of animal-drawn equipment - to the tractor. Many of the farmers have been so used to the traditional tools like the hoe, the cutlass and the axe that they are afraid of handling the tractor and machines. According to Khanna (1983), 29 out of every 38 who have machines in Madhya-Pradesh, India, give them out to family members to handle, while only 9 out of every 20 handle their own machines by themselves (see Table V, page 42).

**THE PROBLEMS OF AGRICULTURAL MACHINERY MAINTENANCE
AND NEW APPROACHES TO MAINTENANCE IN DEVELOPING COUNTRIES**

According to Crossley and Kilgour (1983), the two tools of maintenance are spare parts and trained personnel. These two tools alone cannot solve the myriad of problems facing agricultural machinery maintenance in developing countries. These problems include:

1. Lack of capital or low income.
2. Lack of technical knowledge by owners and operators.
3. Lack of trained personnel - mechanics and technicians.
4. Insufficient spare or replacement parts.
5. Inadequate after-sale service.
6. Lack of standard workshops.
7. Non proximity to dealers and manufacturers.
8. Transportation.
9. Poor selection and management of equipment.
10. Politics.

Lack of Capital or Low Income

As pointed out previously, agricultural production is still basically traditional in many developing countries. It is operated on family-oriented technology, rotational bush-fallow method of cultivation and small holdings based on locally-made implements. According to Crossley and Kilgour (1983), in Kenya, Peru, Sri Lanka, Botswana and Mexico, the gross income per capita is about \$250 per year. Olatunbosun (1975) reported ninety four naira (94.) or \$141 as the income per capita of the rural farmers in Nigeria in 1970. This has not changed so much today, especially with the devaluation of the naira. With small

earnings from small holdings, it is economically difficult for many farmers in developing countries to buy their own machinery. Where they have, they are unable to maintain their machinery adequately and still care for their families.

The new approach to solving the lack of capital is the establishment of agricultural banks. These banks are expected to grant loans to farmers at low interest rates to buy land for agricultural purposes and purchase agricultural inputs. But lack of collateral securities is still a limiting factor to many farmers getting farming loans.

Lack of Technical Knowledge

Many machinery owners and operators in developing countries have no technical knowledge of the many machines they operate. Many of these people are illiterates who can neither read nor write. Even those who are fairly literate do not know how to read the owner's manuals of their machines. It is very necessary for the fulfillment of the four objectives of maintenance, already mentioned, that every operator should learn the correct operating and maintenance procedure of his equipment. A modicum of technical knowledge is vital for effective machinery handling.

Most family members who handle tractors in developing countries are the disgruntled, ill-treated, school dropouts. They have no value for the life of the machinery. They run the tractor daily without care and maintenance. They think that the tractor is not due for maintenance until it can no longer start. Some tractor owners use their elementary school children to operate equipment. These children are not taught by their parents so they constantly ride on both clutch and brake pedals.

In Nigeria, the new approach to overcome mishandling of agricultural machinery is the government law that craftsmen or tractor operators should be above 18 years of age. They should also be required to pass a trade test. The ownership of a driver's license does not qualify any person to operate a tractor any more in Nigeria.

Lack of Trained Personnel

There is a dearth of trained mechanics and technicians for the maintenance of agricultural machinery in developing countries. In developing countries, automobile mechanics and technicians frequently operate as agricultural machinery trained personnel. This practice should be stopped. It is not ideal, because automobile personnel are not trained on the matching of equipment to task. They are not trained on machinery selection and calibration. For instance, an automobile mechanic is not trained on the concepts of tractor drawbar power. There are three possible adjustments on the drawbar: lengthwise, horizontal, and vertical. Adjustments can be made, depending upon the circumstances, to obtain improved drawbar performance (see Table VI, page 42). Failure to make correct adjustments and calibration on agricultural machinery often leads to poor performance and often breakdowns.

To overcome this problem, many developing countries in the early 1970's upgraded many Schools of Agriculture to be part of the Universities. This method has helped to turn out agricultural assistants and agricultural superintendents who have sound technical knowledge in agricultural engineering.

Lack of Sufficient Spare Parts or Replacements

Many developing countries such as Jordan, Egypt, Iran, Iraq, Morocco, Tunisia, Syria, Zambia and Tanzania depend on importation of agricultural machinery. According to Khalil (1981), although the Egyptian government has made provisions for the importation of agricultural machinery, spare parts are often not available. Such provisions include:

1. Low rate of custom duties for imported farm machinery.
2. Exemption of cooperative societies from tariffs on farm machinery.

In 1968, there were 3,719 imported tractors in Egypt. In 1973, this number dropped to 1,500 tractors and between 1974 and 1977, there were 6,061 tractors imported. In 1979, there was a total of 29,352 imported tractors in Egypt. He concluded that farm equipment importers were never motivated to import spare parts. They were only interested in the highest profit for the least effort.

In the 1960's, before the assemblage of Fiat and Steyr tractors in Nigeria, the government made it mandatory for importers of agricultural machinery to include 10% of their total cost for spare parts. The directory was strictly adhered to initially, but when the bureaucrats became corrupt, the importers brought in more equipment and less spares. This trend continued until many government farms became littered with grounded machinery. Some machinery, after one or two years of operation, were cannibalized due to lack of spare parts. Minor parts like V-belts, control cable, etc. resulted in sending a one-year old tractor to the junkyard. This situation was rife in many developing countries.

Inadequate After-Sale Service

According to Gego (1986), the market acceptance of agricultural machinery is greatly dependent on proper after-sale service which consists of free essential parts, annual maintenance, warranty certificates, operating instruction booklets, parts catalog and pamphlets.

In industrialized countries, like the United States of America, large tractor manufacturers, like John Deere and International Harvester, have well-organized dealership network. They often provide two after-sale services; one after 50 hours and the other at 200 hours.

In developing countries, there is no well-organized dealership network. After-sale service is a haphazard business. In Turkey and Pakistan where there are tractor factories, and in Nigeria where there are two tractor assembly plants, the amount of commission allowed to dealers by the government is not enough to cover two services. In Pakistan, because of a low commission (Rs. 800-1500/tractor), the dealers could not establish proper workshops - *ibid.* See Table VII, page 43 for the mode of sale of products of small, medium and large scale manufacturers. There are only six dealers of small scale manufacture for all of Pakistan. This number is inadequate.

Between 1979 and 1983, Yakon Company sold many agricultural machines in Nigeria. The Company could not carry out more than one after-sale service on each of the tractors delivered to six states in the Federation. The commission paid by the federal government to dealers was only one hundred and fifty dollars per tractor. Therefore, we were neither in position to take care of the farmer's machinery properly nor

provide advisory service to them. I designed a plan whereby the farmers could deposit some money with the company. The company would then maintain the machinery and charge the cost to the farmer's account with the Company. The farmers turned the plan down. Now, the federal government has increased the commission to four hundred fifty dollars per tractor.

Even in Turkey and Pakistan where small and medium scale manufacturers claim they provide after-sale service to their customers, the latter had to bring their faulty machines to the manufacturers' workshops. Rarely were mechanics ordered to attend to the complaint on the spot. Hence, the majority of the customers from remote areas could not avail of the after-sale service facilities (Gego, 1986).

Lack of Standard Workshops

This is one of the major problems resulting in inefficient machinery maintenance in developing countries. There are three classes of workshops, according to Crossley and Kilgour (1983):

1. Farm workshops for preventive maintenance,
2. Repair workshops, for corrective maintenance, servicing, and
3. Mobile workshops, for both preventive and corrective maintenance.

Farm Workshops - According to Binswanger (1984), the tractorization of European and Japanese agriculture around 1955 was simultaneously followed with the development of farm workshops to carry out simple maintenance. This gave Japan massive spurts in mechanization so that between 1939 and 1955, power tillers rose from 100,000 to 3 million.

In developing countries, farm workshops are few except in China, Japan and Taiwan. In countries like Uganda, Tanzania, Ghana, and

Burkina Faso, the few farm workshops that are erected are inadequate.

They lack the essential features of modern farm workshops such as:

1. Concrete floor, good drainage, protection from rain and sun and large enough to store all the equipment and provide enough space to enable people to walk around.
2. Spare parts store area.
3. Fuel and lubrication store.
4. Tools.
5. Instruction books and Owners' manuals.

To solve this problem, the governments are establishing standard workshops in government farms as models for the farmers.

Repair Centers

Repair centers are operated by private mechanics and companies in the cities. There are many in Venezuela, Bangladesh, Sierra-Leone, Indonesia, Senegal and Nigeria. There are many complaints about them.

1. Gap between work and maintenance. In Egypt, the number of repair workshops is very few compared to the number of tractors. There should be a balance between the number of tractors and the number of service centers and the amount of spare parts (Khalil, 1981).
2. Exorbitant charges.
3. Employment of non-qualified technicians.
4. The non-challant attitude of the mechanics to farmer's complaints.

Mobile Workshops

I like to describe them as workshops on the wheels. They have recently been operated by the government in some developing countries to bring maintenance closer to the farmers. This system is in operation in

Nigeria, Zimbabwe, Ivory Coast and Indonesia through the Tractor Hiring Unit System. It started in Nigeria in the early 1980's; it is yet too early to judge its effectiveness. Reports indicate that the commercial farmers are applauding the scheme.

Non-Proximity to Main Dealers or Manufacturers of Agricultural Equipment

This is a serious problem. Machinery owners live in the rural areas while the dealers/manufacturers live in the urban centers. In developing countries, there is a poor dealership program. A farmer travels long distances, at least fifty miles, to buy a replacement part from a dealer in order to maintain his machinery.

Between 1980 and 1981, Yakon Company delivered many farm implements to federal agricultural stations in six states in Nigeria. The Company was more than two hundred miles from some of the stations. A steady and routine maintenance schedule with the distant stations was very difficult.

To solve this problem, the federal government in 1984 directed that machinery dealers could only be given contracts to supply machinery within their own state. This was to bring the dealers/manufacturers closer to the machinery owners for ease of maintenance.

Transportation

In many developing countries like Nigeria, Columbia, Gayana, Zaire, and Cameroun many highways and farm roads are seasonal. They are usually flooded during the rainy season which is also the time of peak use of farm machinery. It is not easy, therefore, to transport damaged parts from the farm to repair workshops in the cities.

Recently in Nigeria, farm roads are being tarred, especially those

leading to government farm settlements, which are centers of young and modern farmers with a relatively high concentration of farm machinery.

Selection and Management of Farm Machinery by
Farm Managers/Machinery Purchasers

According to Hunt (1964), there are two machinery selection concepts:

1. Capacity selection -- based on costs, operations, power, and performance characteristics.
2. Functional selection -- best made after field trials with specific machines in actual field situations.

Culpin (1969) found that machinery management has three phases:

1. Choosing equipment for the farm.
2. Learning best techniques for operating equipment.
3. Evolving a system of maintaining the machinery efficiency.

The negative impacts or consequences of wrong machinery selection by farm managers and machinery purchasers are three-fold:

1. Bad matching of equipment which increases maintenance requirements.
2. Shortening of the useful life of machinery.
3. Loss in output.

Machinery selection and management are no longer made by personnel without technical knowledge. With the increase in university education, more educated farm managers and machinery purchasers are now available. In many developing countries, agricultural engineers and mechanization officers now purchase and manage farm machinery.

Politics

This is a serious problem for agricultural machinery maintenance in countries like Nigeria, Ghana, Liberia, Sri Lanka, Korea, Philippines where the government is very unstable. There is alot of discontinuity

in farm mechanization policies. Many machines that are purchased by one government are abandoned by a successive one. In 1979, during President Shagari's government in Nigeria, only political stalwarts were given letters of credit to import farm machinery. The importation was without 10% spare parts. They were playing a game. The earlier the machinery was grounded due to lack of spare parts for its maintenance, the sooner they would get a contract to supply new ones. Under the present military rule of President Babagida, new dealers have been appointed. All deliveries are now accompanied with 10% spare parts for maintenance.

THE BENEFITS OF MAINTENANCE AND A MODEL FOR MAINTENANCE PROGRAMS IN DEVELOPING COUNTRIES

Crossley and Kilgour (1983) observed that machines are inanimate objects which have no power of regeneration. It is my belief that maintenance is the process of regenerating machinery.

Crossley and Kilgour (1983) found that machines are designed for a number of hours life, e.g. medium-sized agricultural tractor for 10,000 hours provided that:

1. Certain parts are replaced regularly.
2. Parts are not allowed to degrade through corrosion.
3. Broken parts are replaced before further damage is caused.
4. Oil and air filters and oil are changed at specified intervals.

With optimum maintenance, a tractor can have a useful life of at least 6,000 hours. When maintenance is not performed, a tractor can be uneconomic to keep, especially when it is in the workshop more hours than it is used for productive work.

Lack of tractor maintenance can result in:

1. Degeneration of the plastic components exposed to the sun.
2. General fatigue problems, e.g., cracks and broken welds in the main structure or loose bolts and nuts.
3. Long and expensive breakdowns.
4. Loss of time and money.
5. Engine damage.

On the other hand, the benefits of maintenance cannot be overemphasized.

1. It offers dependable, reliable and functional equipment.
2. It extends the useful life of assets.

3. It insures availability or readiness of the system.
4. It permits timeliness of operations.
5. It gives greater efficiency to machinery.
6. It lowers unit cost of production by allowing increased output.
7. It allows maximum return on investments.
8. It insures safety of personnel.
9. It can increase cropping intensity and patterns, e.g. the availability and use of a well-maintained tractor may release land previously used for fodder, since draught animals are no longer required (Khalil, 1981).
10. It increases the rate of adoption. The first few mechanization programs must be successful, if others are to be favorably impressed by the system.

A model for maintenance programs in developing countries should include:

1. Planning - The farmer should plan out the number of agricultural machinery he can afford to buy and maintain.
2. Convey farm machinery with low loaders or trucks.
3. Observing a running-in period. During this period, the machinery operator should torque loose bolts and nuts. The sump oil should be drained early, because of break-in wear.
4. After-sale service carried out by dealers/manufacturers.
5. Use of owners' manuals in native language to guide operators of machinery on daily and routine maintenance.
6. Use of Instruction books by mechanics and technicians so that they are technically equipped to carryout effective repairs on specific

machinery.

7. Calibration of machinery carried out at the beginning of each season before and during actual field operations to avoid over-and-under plant population per acre.
8. Tires should be inflated to the correct pressure. Overinflation leads to less rate of planting while underinflation causes small errors in the rate of seeding per acre.
9. Most of the machines should be housed to keep them out of the rain and the sun.
10. Workshops should be used to diagnose all machinery faults just as any sick person is sent to the hospital for treatment. Each workshop should have standard tools and safety facilities.
11. Each workshop should have a spare part store, good control and an ordering pattern.
12. Maintenance programs should have an ideal workshop labor requirement of three classes:
 - a. Mechanic - one trained mechanic to 10 tractors and associated equipment with one skilled assistant.
 - b. Foreman - To be in charge of one welder/storeman and five mechanics.
 - c. Manager - One full time manager is necessary to control the workshop. He should insure that the workshop job card has three items on it:
 - i. What the mechanic should do.
 - ii. The spare parts used.
 - iii. The time taken for the repair.

13. The tractor operator should spend about thirty minutes each day to maintain his machinery:

- a. Fifteen minutes in the morning for all checks: sump, radiator, battery, tires, light, horn, etc.,
- b. Fifteen minutes after the lunch hour to keep the tractor free from dust and re-check equipment calibration.

At regular interval, before the closing hour, the tractor operator should clean and lubricate the machinery. If the tractor is to be washed, water should not be allowed in bearings and lube compartments. It may cause more harm than good.

CONCLUSIONS AND RECOMMENDATIONS

The available power on the farm in developing countries is yet very low compared with industrialized countries. Imagine 0.05 hp/ha in Africa compared to 4.7 hp/ha in West Germany (see Table VIII, page 43). The increase of power on the farm through machinery maintenance is very vital to mechanized agriculture in developing countries.

The rapidly growing populations of the developing countries will need more food in the future. The increase can be obtained by increasing the output per cultivated area, expanding cultivated area and raising the number of harvests per year through irrigation. These are possibilities through farm mechanization policies that are founded on well-maintained machinery.

1. Importation is still the major source of agricultural machinery in developing countries; but efforts should be geared toward local manufacture with minimum of importation.
2. There should be good selection and management of agricultural machinery by machinery buyers and operators respectively so that well-matched equipment is available for different tasks.
3. There is inadequate maintenance of agricultural machinery in developing countries, because spare parts are not readily available and trained personnel are very few.
4. There is an urgent need for the establishment of Mechanization Schools in developing countries to educate all machinery users on the importance of machinery maintenance and how to carry out simple machinery maintenance.

Here are my recommendations:

1. Binswanger (1984), found that agricultural mechanization and machinery maintenance in developing countries did not depend on direct government intervention in machinery development, production, terotechnology/maintenance, selection or finance as in Taiwan (China) and Thailand. Once economic conditions have led to effective machinery demand and maintenance, private firms have responded rapidly in the developed world. I recommend, therefore, that government policy on machinery maintenance should be confined to:

- a. Patent laws for the enforcement of innovator's rights and encouragement of disclosure effects.
 - b. Testing of machinery, support of standardization measures and information dissemination.
 - c. Support of agricultural engineering education and some university based research.
2. Governments in developing countries should allow importation and manufacture of agricultural machinery to occur at the same time so that small innovating firms can see foreign designs from which they can create locally adaptable and manageable machines with less complicated accessories. This was the Japanese success story in the 1950's.
3. Conventional farmers need to establish their own standard workshop for the maintenance of their agricultural machinery rather than depend on government-operated mobile workshops. Such farm workshops should have an ideal spare parts control system (see Table IX, page 44). The farmer should make it a

firm rule that when a bin gets down to the last two items, the label should be put into the order box.

4. The governments in many developing countries should pass a law that no machine should be sold unless it has:
 - a. An Instruction Booklet,
 - b. Parts List,
 - c. And Service Manual - all written in native language.
5. National mechanization schools like the one in Illorin, Nigeria, should be opened in many developing countries to train tractor operators, mechanics and technicians, farm managers and machinery-purchasing officers on the use and maintenance of agricultural machinery. The Schools should test all tractors like the Nebraska Tractor Testing in the United States of America.
6. After-sale service commission should be raised so that dealers and manufacturers can carryout after-sale services.
7. Farmers can form a Farm Machinery Syndicate consisting of about three neighbors who agree to purchase, use and maintain particular machines in proportion to their needs. This will help to reduce maintenance costs to the individual farmer where a cooperative society has not been formed.
8. The development of a partial or selective mechanization of pre-harvest and harvest operations and the use of general - purpose tractors rather than standard tractors. This may reduce the farmer's operational costs and leave him with some money for the maintenance of his machinery.

9. Workshops should be equipped with fire extinguishers (dry chemical, soda acid, gas pressure, fire buckets or fire blanket). Many tractors have burned in the workshop when there was no fire extinguisher. Other safety equipment should include clothes (protective), goggles, gloves, breathing masks and ear plugs.
10. Workshops should be provided with the following five basic tools:
 - a. Compressed air equipment, if the farmer can afford it.
 - b. Lifting equipment
 - c. Cleaning equipment - for daily maintenance
 - d. Lubrication and fuel
 - e. Welding equipment
11. All equipment should be housed in a storage building to keep it out of the rain and the sun in order to prevent rusting, corrosion, degeneration of the chassis.

Many developing countries are revolutionizing their agriculture through mechanization without adequate attention being paid to machinery maintenance. Maintenance will help greatly to bring down the unit cost of mechanization, increase machinery output and reduce downtime. A well-developed market system for harvest inputs will surmount the problem of glut at harvest time. This may bring more income to the farmer to buy spare parts and hire trained personnel to maintain his machinery.

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TABLES

Table I. Machinery Supply in Developing Countries

S/No	Source	%
1.	Importation	50
2.	Local manufacture	30
3.	Assembly plants	20

Sources of Data: Khana (1983)

Table II. Comparison of Average Incomes in Urban and Rural Area in Nigeria

Occupational Groups	Average Income (#)					
	1963			1970		
	Urban	Rural	Rural/ Urban	Urban	Rural	Rural/ Urban
Professional Management and Technical	3,686	974	0.26	3,930	1,034	0.26
Clerical and Minor Professional	476	308	0.65	628	380	0.61
Skilled & Semi-Skilled	328	196	0.60	476	274	0.58
Unskilled	160	102	0.64	190	112	0.59
Farmers	100	102	0.64	148	94	0.44

Source of Data: Olatunbosun (1975)

Table III. Distribution of the Cultivated Agricultural Area In Developing Countries and in Industrialized Countries According To Stages of Mechanization in 1975. (acc. to FAO, 1979).

Stage of Mechanization				
Item	Manual Work	Use of Drought Animals	Use of Tractors	Total
Developing Countries:				
cultivated area, 10 ⁶ ha	125	250	104	479
relative percentage, %	26	52	22	100
Industrialized Countries:				
cultivated area, 10 ⁶ ha	44	63	537	644
relative percentage, %	7	11	82	100
World Total:				
cultivated area, 10 ⁶ ha	169	313	641	1,123
relative percentage, %	15	28	57	100

Table IV. Need For Tractor In The Chambal Region of Mahya Pradesh in India

S/No	Need	Number	%
1.	Yes	11	11
2.	No	72	72
3.	Non-reporting	17	17
Source of Data: Khana (1983)			

Table V. Handling of Machines in the Chambal
Region of Madhya-Pradesh, India

S/No	Handling Person	Number of Respondents	%
1.	Yourself - Owner	25	36.23
2.	Family Member:		
	Man	38	70.07
	Lady	--	---
3.	Servant	6	8.70

Source of Data: Khana (1983)

Table VI: Tractor Drawbar Power Adjustments

Lengthwise	Horizontal	Vertical
Use the pivot pin and put the swinging drawbar in the short position	Find the center of load or draft, e.g. for a 3-14 in. bottom plow. Solution: Total Cut = $3 \times 14 = 42$ in. Center of Cut = ____ = 21 in. $1/4$ of width of one bottom = ____ = $3 \frac{1}{2}$ Center of load = $21 + 3 \frac{1}{2} = 24 \frac{1}{2}$ in. from last furrow wall.	Use the hitch crossbar, and never too low or too high. Too low - drive-wheel Slippage & drawbar in trash. Too high - lightness of front end of tractor and poor steering.

Source of Data: Johnson and Hollenberg (1950)

Table VII. Mode of Sale of Products of Small, Medium and Large Scale Manufacturers in Pakistan

Category	Direct Sale (%)	Dealer Network (%)	Number of Dealers
Small	97.5	47.5	6
Medium	100	50	8
Large	100	100	45

Source of Data: Gego (1986)

Table VIII. Power Availability on the Farm

S/No	Country/Continent	Power/ha
1.	West Germany	4.7 hp/ha
2.	USA	1.02 hp/ha
3.	Europe	0.93 hp/ha
4.	Latin America	0.27 hp/ha
5.	Asia	0.19 hp/ha
6.	Africa	0.05 hp/ha

Data Source: (acc. to FAO, 1974)

Table IX. Spare Parts Control

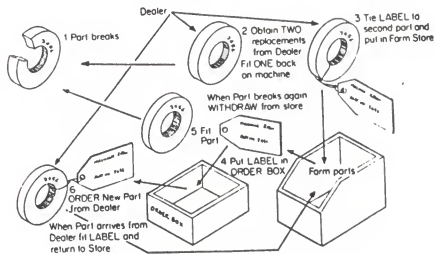


FIGURE 12.4 Spare parts control (after ADAS, 1978)

AGRICULTURAL MACHINERY MAINTENANCE IN DEVELOPING COUNTRIES

by

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B.S. Western Illinois University, 1985

AN ABSTRACT OF A MASTER'S REPORT

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ABSTRACT

This report deals mainly with agricultural machinery maintenance/terotechnology in developing countries - Asia, Africa and Latin America. The word machinery includes all the factors that effect agricultural mechanization, and they are mainly tractors and implements. The report emphasizes the tractor, because it is the major tool for agricultural mechanization in developing countries.

The report aims at determining the sources of agricultural machinery, the present status of agricultural machinery maintenance, the problems of and the new approaches to agricultural machinery maintenance, and a model for agricultural machinery maintenance programs in developing countries.

It overviews importation, local manufacture and assembly as the sources of agricultural machinery in developing countries. Also, the influence of the methods of tractorization - ownership of tractors, tractor hiring system, custom work and cooperative society - on machinery maintenance. A general survey is made on the problems of agricultural machinery maintenance and the new approaches to solving the problems, the benefits of machinery maintenance, and a model for machinery maintenance programs are fully presented.

Finally, the report concludes that:

1. Importation is still the chief source of agricultural machinery in developing countries.
2. There is insufficient supply of spare/replacement parts for agricultural machinery maintenance in developing countries.
3. There is lack of trained personnel to maintain machinery in developing countries.
4. A National Mechanization School should be established by every nation in the developing world to train machinery personnel and test all tractors.